

Cascade Storage and Delivery System for a Multi Mission Space Exploration Vehicle (MMSEV)

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NASA is developing a Multi Mission Space Exploration Vehicle (MMSEV) for missions beyond Low Earth Orbit (LEO). The MMSEV is a pressurized vehicle used to extend the human exploration envelope for Lunar, Near Earth Object (NEO), and Deep Space missions. The Johnson Space Center is developing the Environmental Control and Life Support System (ECLSS) for the MMSEV. The MMSEV's intended use is to support longer sortie lengths with multiple Extra Vehicular Activities (EVAs) on a higher magnitude than any previous vehicle. This paper presents an analysis of a high pressure oxygen cascade storage and delivery system that will accommodate the crew during long duration Intra Vehicular Activity (IVA) and capable of multiple high pressure oxygen fills to the Portable Life Support System (PLSS) worn by the crew during EVAs. A cascade is a high pressure gas cylinder system used for the refilling of smaller compressed gas cylinders. Each of the large cylinders are filled by a compressor, but the cascade system allows small cylinders to be filled without the need of a compressor. In addition, the cascade system is useful as a "reservoir" to accommodate low pressure needs. A regression model was developed to provide the mechanism to size the cascade systems subject to constraints such as number of crew, extravehicular activity duration and frequency, and ullage gas requirements under contingency scenarios. The sizing routine employed a numerical integration scheme to determine gas compressibility changes during depressurization and compressibility effects were captured using the Soave-Redlich-Kwong (SRK) equation of state. A multi-dimensional nonlinear optimization routine was used to find the minimum cascade tank system mass that meets the mission requirements. The sizing algorithms developed in this analysis provide a powerful framework to assess cascade filling, compressor, and hybrid systems to design long duration vehicle ECLSS architecture.

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